THREE INEXPENSIVE AQUATIC INVERTEBRATE SAMPLERS FOR THE BENTHOS, DRIFT AND EMERGENT FAUNA[1]

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ABSTRACT: Construction plans and methodology are provided for three easily constructed, low cost aquatic macroinvertebrate samplers: a benthic sampler, an adjustable aquatic drift net, and an insect emergence trap. Costs for materials and construction-time estimates are provided.

The quantitative assessment of benthic aquatic invertebrates is often central to the goals of ecological research. Three common quantitative sampling devices used to measure aspects of aquatic invertebrate populations are the benthic sampler (e.g., Surber and Hess samplers), drift net, and emergence trap. Several varieties of these sampling devices are commercially available (Merritt and Cummins 1984); and plans for homemade samplers have been published (e.g. Mackie and Bailey 1981; Brown 1984). My principal criticism of commercial samplers is the high cost of these 'standard-dimensioned' samplers which often do not fit the needs of the research program. In my experience, having a sampler built commercially to the dimensions (e.g., mesh size or sampled area) appropriate for a specific research goal nearly doubles the cost. Homemade sampling devices are generally less expensive than those commercially supplied, but are often difficult and time consuming to construct. In the field, many of these devices are too heavy or complicated; the tenets of simplicity appear to have been ignored. This paper provides plans and construction methodology for three low-cost, easily constructed samplers: a benthic sampler, an adjustable aquatic drift net, and an aquatic insect floating emergence trap.

Benthic Sampler

The most commonly used benthic macroinvertebrate sampler is one which defines an area of bottom from which organisms are collected. Following are construction plans and methods for a benthic sampler that costs about $75 for materials and takes less than 4 hrs construction time (Table 1). This sampler is designed for collecting in shallow, flowing water but may be modified for use in deeper or nonflowing water.

An 8 inch (21 cm) PVC sewer T-joint serves as the frame of the sampler (Fig. 1a). Different sized T-joints (sizes up to 24 in.) may be acquired to fit specific research needs. Two 7 x 2 3/4 in. (18 x 7 cm) holes are cut in the front wall opposite the junction orifice. These holes allow a current to flow through

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[1]Received March 6, 1987. Accepted April 13, 1987

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the sampler and carry organisms lifted from within the sampler into the collection net. The junction orifice, to which the collection net will be attached, is shortened to extend only 1 in. (2.54 cm) beyond the outside wall. The final cuts in the frame are 3/8 in. (1 cm) deep, 2 1/2 in. (5.7 cm) long crenations cut into what will become the bottom of the sampler. Silicone rubber is used to glue fiberglass window screening over the 7 x 2 3/4 in. openings in the sampler's front wall. A mesh size larger than that used in the collection net will allow a rapid flow rate through the sampler and prevent drifitng organisms outside the sampler from inadvertently entering the collection net. The mat stripe of 3/4 in. Velcro® tape is glued with silicon rubber to the 1 in., outside lip of the junction orifice.

The collection net for the benthic sampler (Fig. 1b) is constructed of 363 micron mesh netting (Nitex®); however, any mesh size may be used. The open end of the net bag is made slightly larger than the outside diameter of the sampler's junction orifice, 9 1/2 in. (24 cm) in this case. The net pattern is cut in the shape of a large isosceles triangle. One side of the triangle must be long enough to encircle the PVC pipe junction orifice (28 3/8 in. or 72 cm). The length of the other sides, which determines the net length and volume, depends on the requirements of the investigation. For my research on smaller (2nd order) streams, a length of 28 3/8 in. (72 cm) worked well. To construct the net bag, the two equal edges of the netting material are rolled and sewn together with two stitchings (double seam) of nylon thread or light weight monofilament fishing line (Fig. 1b). Place a double row of stitches about 3 in. (7.6 cm) from the narrowed end of the collection net. Sewing these stitches in the shape of a slight arc greatly increases the ease of sample removal. Lightly cover frayed edges with silicone rubber, let dry, and trim. With the rolled edge turned inside the net and the smoothest side out, the hooked strip of the 3/4 in. Velcro tape is sewn to the outside rim of the net. The net is turned so that the Velcro strip is inside the opening and then slipped over the Velcro mat strip of the frame junction orifice. The net is constructed so that frayed ends or rough surfaces do not impede movement of sampled organisms to the constricted end of the net. The Velcro tape allows easy attachment of the net to the sampler.

This sampler is easily modified for use in water deeper than the sampler height 17 in. (43 cm). A mesh sleeve is attached to the top of the sampler which allows the researcher to reach into the sampler while preventing escape of organisms. The mesh sleeve is constructed using roughly the same dimensions and pattern as the collection net, but inexpensive mosquito netting may be used. The Velcro tape may be attached to the top of the sampler and sleeve as it was to the junction orifice and collection net, however, a strong elastic band stretched over the sleeve and around the top of the sampler also works well. The sleeve differs dimensionally from the

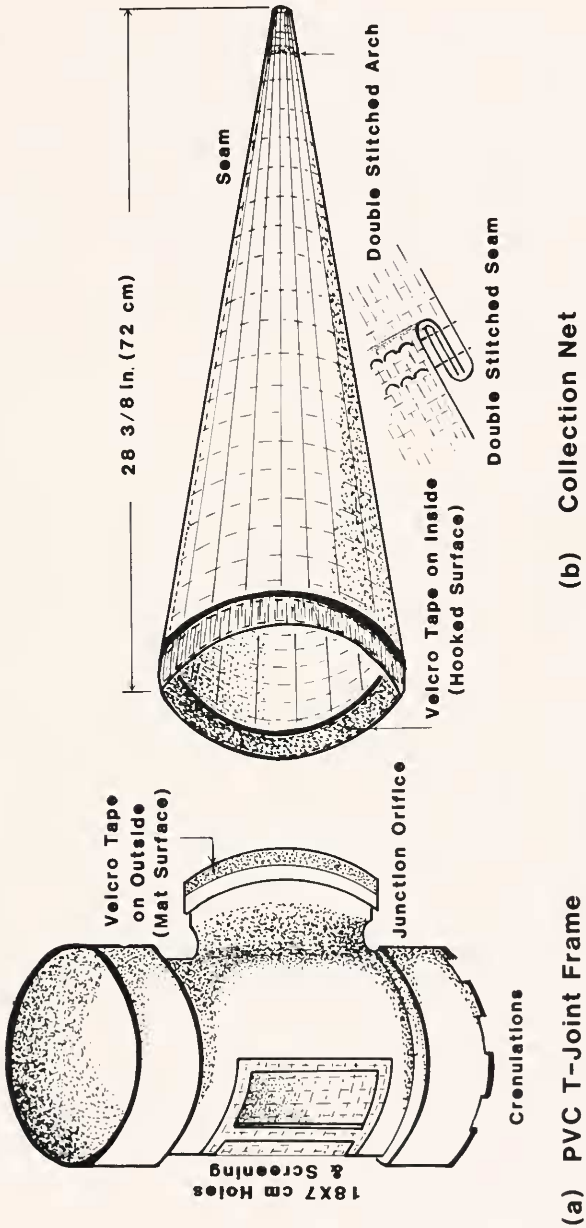

Fig. 1. Benthic sampler. (a) Eight inch PVC T-joint (sampler frame). (b) Collection net with double stitch seam inset.

collection net only at the constricted end. Here the net is shortened three inches (7.6 cm), leaving an opening through which an arm may fit.

Samples may be taken in non-flowing water by adding a diaphragm pump to the system. The inflow hose of the pump may be attached to a brush for scrubbing surfaces. The outflow hose, attached to the front of the sampler (flow directed rearward), provides a current within the sampler that carries organisms into the collection net.

To use the sampler, press the frame with attached net onto the substrate and revolve in both directions until the side orifice comes in contact with the substrate (crenations on the frame bottom facilitate rock displacement better than a smooth-edged frame). The bottom of the sampler is now 4 in. (10 cm) into the substrate, a depth at which Williams and Hynes (1974) found the greatest biomass and number of organisms. Using this method, samples are consistently quantified on a volumetric basis (organisms/m^3) as well as by surfaces area (organisms/m^2).

Drift Sampler

The movement of aquatic organisms with the current of flowing water is commonly referred to as drift (reviews by Waters 1972, Muller 1974). Sampling drifting organisms in a variety of stream and river types requires many different types and dimensions of drift nets. The drift sampler discussed below has adjustable inflow dimensions, is lightweight, and can be completely dismantled for easy transportation in the field. It takes about two hours to construct and costs about $56 (Table 1).

The frame is constructed of 1/2 in., schedule 20, PVC pipe, and cross-joints fitted together to form a rectangle (Fig. 2a). The length of pipe can be varied to accommodate the appropriate cross sectional area of the water column that will be sampled. The net, constructed of 363 micron mesh netting (Nitex®), is sewn to a Cordura® apron (other moisture resistant material may be used for the apron) and the apron is attached to the drift frame (Fig. 2b). The net material is cut as a single piece. The long cut edges are rolled twice and sewn together lengthwise with a double seam of nylon thread. Six inches (15.2 cm) up from the constricted end of the collection net an arch is double stitched. As with the benthic sampler, this makes sample removal much easier. The open edge of the Nitex is folded once and double stitched against the exterior edge of the Cordura apron. This creates a downstream facing lip which should deter upstream movement of crawling invertebrates that have entered the drift net.

The frame edge of the apron is folded back 2 in. (5 cm) and sewn along the cut edge to form a tube into which the PVC pipe will be positioned. All frayed edges of the net and the apron should be coated with silicone and trimmed. Apron and net sections of the sampler are designed for a frame that measures 24 in. (61 cm) by 12 in. (30.5 cm) but will easily

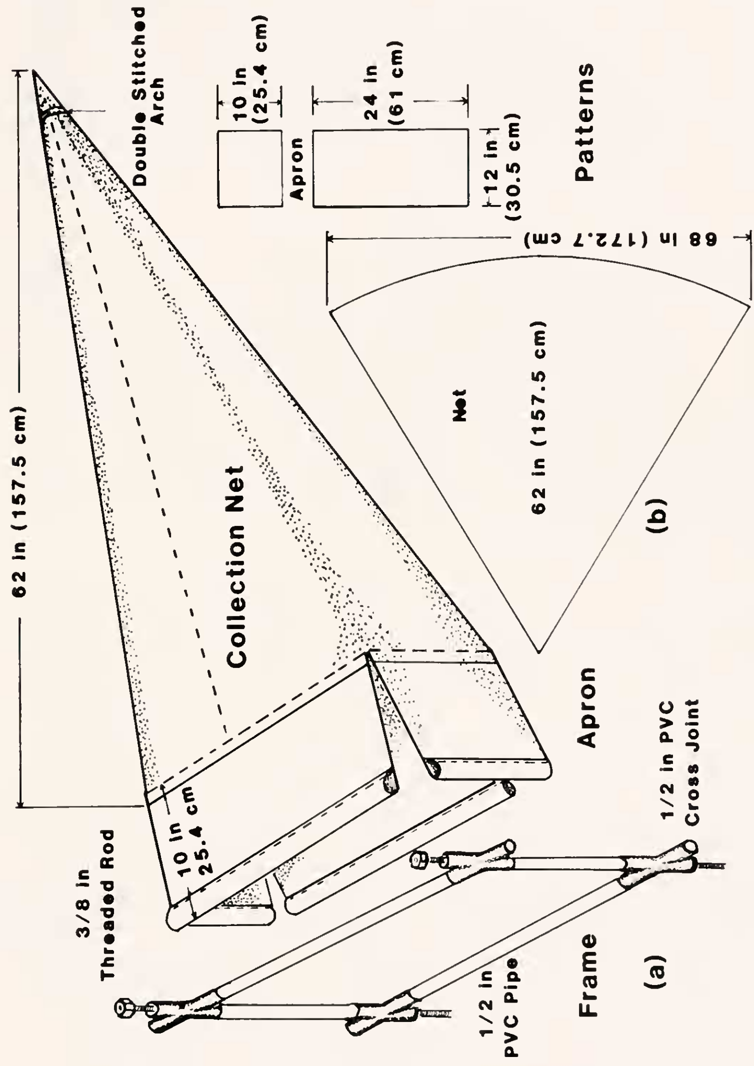

Fig. 2. Drift sampler, (a) Sampler frame of 1/2 in. PVC pipe and cross-joints held in position by 3/8 in. threaded rod, depth in channel adjusted by 3/8 inch nuts. (b) Collection net with patterns for net and apron panels.

accommodate smaller frame sizes. Frame size is reduced simply by shortening the lengths of PVC pipe. Frame sections of the sampler should not be glued together so that the sampler can be dismantled for easy transportation in the field. If the stream to be sampled is very narrow or deep, the net may be stood on end. The sampler is staked to the substrate with two threaded rods passed through the frame. A set of nuts on the rods allows for adjustment of the sampler's height in the water column. This drift sampler is easily constructed and inexpensive. The extremely large net of my prototype (ca. 25 ft^2) accounted for 75% ($41.55) of the total cost (Table 1).

Emergence Trap

There are many designs for traps which capture emerging aquatic insects (Merritt and Cummins 1983). Often these are difficult and expensive to construct and removal of organisms from the trap may be difficult and result in the loss of organisms. Some traps require aspiration of the insects from inside the trap or the trap must be tipped or inverted to remove the collected insects. The emergence trap (Fig. 3) described below is inexpensive ($19) and requires about two hours to construct (Table 1). It is constructed of 1 x 2 in. pine lumber, plywood, fiberglass window screening, a funnel, pint jar, corner plates, and corner braces. The best sequence for construction and methodology follows:

The 9 1/2 x 7 7/8 in. (24 cm x 20 cm) top plate is cut from 5/8 in. plywood and a 6 3/8 in. (15.8 cm) diameter hole is cut in the center of the plate through which the collection assembly is removed. Next, all 1 x 2 in. (2.5 x 5.1 cm) pine strips (without knots) are cut with ends at 45° angles to lengths given in Figure 3a. The base joints of the traps are held together with 1 1/2 in. metal corner plates. The top plate and the angle arms are assembled with 1 1/4 in. metal corner braces (Fig. 3b). A wire loop about 14 cm in diameter (Fig. 3b) is screwed to the underside of the top plate. This loop suspends the collection assembly 10 cm below the top plate and allows the emerging insects easy access to the collection funnel and jar (collection assemblage). The collection assembly (Fig. 3c) consists of a pint jar and lid screw ring to which a funnel has been attached with metal screws. The top plate and angle arm assembly is then attached to the base by corner braces (Fig. 3d). The whole trap frame is covered with marine paint, varnish or other wood preservative. Screening material and mesh size of choice is cut to fit over the side frame openings. The edges are rolled once and stapled in place with a staple gun to the angle arms, top plate, and trap base. A plexiglass cover is cut to fit over the 15.8 cm hole in the top plate. The cover is held in position by beads of silicone glue located just outside the plexiglass cover. Styrofoam strips 2 in. (5 cm) thick are attached to the structure's base for flotation. The trap is then tethered to an anchor or other

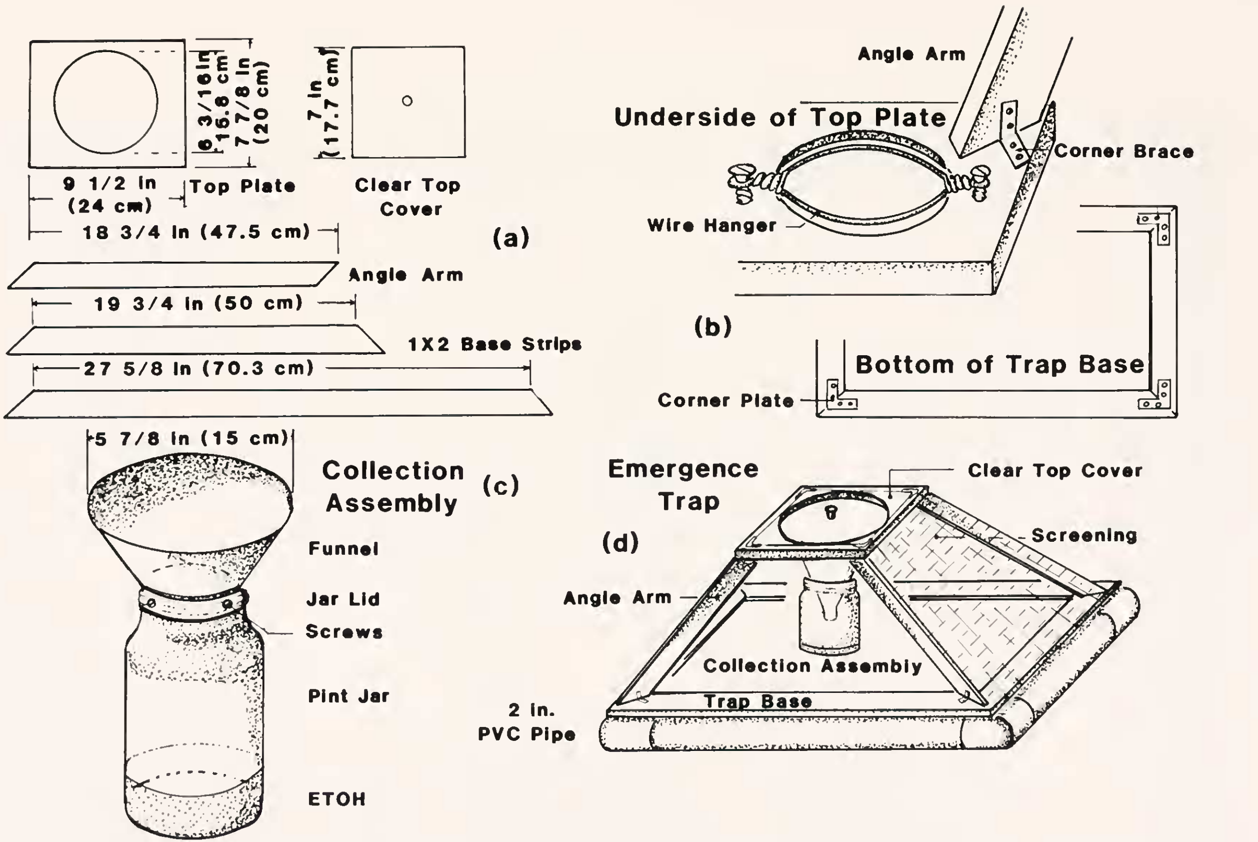

Fig. 3. Emergence trap. (a) Clear top cover and wood cut patterns. (b) Method of assembly for underside of top plate, and bottom of trap base. (c) Collection assembly, consisting of a funnel attached to a jar screw ring, and a pint jar with ETOH. (d) Fully assembled emergence trap with a PVC pipe fotation base.

permanent object. Some modifications may be required for specific research needs. For example, a modification of this type trap was required in a Canadian wetland study where Wrubleski and Rosenberg (1984) found chironomids of the genus *Glyptotendipes* were colonizing the styrofoam

Table 1. Cost of materials and construction time for:

BENTHIC SAMPLER

Item	Quantity	$Cost
8 in. PVC T-Joint		45.00
Nitex Netting	784 in.^{2} (5041 cm^2) @ $41.55/yd	22.20
Velcro Tape	69 in. (174 cm)	5.22
Screen	69 in.^{2} (600 cm^2)	0.70
Thread, Silicon Rubber, Misc. Hardware		3.00
TOTAL COST		75.00
CONSTRUCTION TIME		3.5 hrs

DRIFT SAMPLER

Item	Quantity	$Cost
Nitex Netting	1888 in.^{2} (12.2 m^2) @ $41.55/yd	41.55
Cordura Pack Cloth	6 ft.^{2} (0.56 m^2) @ $1.00/ft.^{2}	6.00
PVC 1/2 in. Cross-joints	4 at $0.75/each)	3.00
PVC 1/2 in. Pipe	6 ft (183 cm) @ $0.14/ft.	0.84
Threaded 3/8 in. rod	two 4 ft. pieces @ $1.35/each	2.70
Thread, Pins and Misc.		1.00
TOTAL COST		55.09
CONSTRUCTION TIME		2 hrs.

EMERGENCE TRAP

Item	Quantity	$Cost
1 x 2 in. Pine Lumber	10 ft. (205 cm) @ $0.30/ft.	3.00
Screening Material	7 x 3 ft. @ $0.50/ft.	3.50
Corner Braces	8 metal 1 1/4 in.	4.00
Corner Plates	4 metal 1 1/2 in.	1.75
Funnel	5 7/8 in. (15 cm) diam.	0.75
Marine Paint or Varnish		0.75
Top plate	9 1/2 x 7 7/8 in. (24 x 20 cm)	1.00
Clear Cover Plate	7 x 7 in. (17.7 x 17.7 cm)	1.00
Hanger wire, Staples, Silicon, Pint Jar.		2.40
Options for flotation:		
a) Styrofoam	3 x 3 x 96 in.	1.00
b) 2 in. PVC Pipe	4 ft. @ $0.50/ft.	2.00
2 in. PVC Elbow	4 @ $1.35/each	5.40
TOTAL COST (with styrofoam float)		19.05
CONSTRUCTION TIME		2 hrs.

floats, resulting in extremely high numbers being collected in the trap and thus biasing his study. Styrofoam based traps did not function well in rivers with extreme fluctuations in discharge. Both these problems were solved by gluing a base-sized loop of 2 in. PVC pipe to the base of the trap (Fig. 3d). However, the use of PVC adds considerable weight and $6.50 to the cost of the trap.

Emerging insects, having flown to the top of the trap will fall into the collection jar containing 95% ethanol. Pint size or larger jars may be used to collect emerging insects and ethylene glycol (antifreeze) may be substituted for 95% ethanol because it does not evaporate as quickly as ethanol (2 weeks for 100 ml). The sample is taken by lifting the clear cover and removing the collection assembly (funnel and attached jar) from the assembly hanger (wire loop) located within the trap. The jar containing the sample is unscrewed from the funnel and a new jar with about 100 ml of ethanol or antifreeze is again screwed to the funnel and the collection assembly is replaced on its hanger. After replacing the clear top cover, the trap is again set to collect emerging aquatic insects.

All three samplers have had at least three years of use in the field. Very little maintenance was required and all functioned well in a variety of habitats. The comparatively low cost, simplicity of construction, and small time investment for construction make these samplers highly desirable to most aquatic researchers.

ACKNOWLEDGMENTS

I thank Peter Adler, Steve Hamilton, John Morse, and Charlie Rabeni for their comments on this manuscript. Funding during development of these samplers was provided by the Columbia National Fisheries Research Laboratory, Columbia, MO and the Missouri Coop Research Unit, Dept. of Forestry, Fisheries and Wildlife, University of Missouri, Columbia, MO. This is Technical Contribution No. 2621 of the South Carolina Agricultural Experiment Station, Clemson University.

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